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PASSENGER EVACUATION STUDIES ON COASTAL PASSENGER VESSEL IN TERENGGANU WATERS

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ABSTRACT

Passenger ship evacuation is a process to mobilize the passenger onboard under the guidance of ship's crew to an assembly area before abandon ship. Accidents involving passenger ships such as MS Estonia and Herald of Free Enterprise caused major losses to property and lives. This led to the introduction of a series of guidelines on the evacuation of passengers for high-speed passenger craft by the International Maritime Organization (IMO). Regulation 21.1.4 of Chapter III SOLAS requires that all survival craft shall be capable of being launched with their full complement of persons within 30 minutes from the time the abandon ship signal is given, and all the passengers have been mustered with lifejackets donned. The maximum allowable passenger ship evacuation is about 60-80 minutes. The purpose of this study is to identify the factors and standards related to passenger ship evacuation and to determine the evacuation time of vessels under the scope of this study. In this study, Pathfinder Thunderhead software is used to create and run a simulation on ship evacuation. This software is meant to simulate evacuation in buildings. However, the software was used to simulate the evacuation of passengers from passenger vessels Laguna Redang P10 and Laguna Redang P9 that are used to transport passengers from Kuala Terengganu to Redang Island and return. Results of the simulations shown that the evacuation time for Laguna Redang P10 and Laguna Redang P9 is 6 minutes 38 seconds and 6 minutes 03 seconds respectively. These results complied with the standard performance set by IMO. As a conclusion, Laguna Redang P10 and Laguna Redang P9 complied with IMO's standard on passenger evacuation time.

Keywords: passenger vessel, passengers, evacuation time.

1. INTRODUCTION

As the year passes by, the development of ship grows into more advances in the term of size, propulsion system, and other new machinery, especially for passenger ships. Passenger ships are estimated to carry a total of 25.8 million passengers in 2017 and this number had increased by 62% over the past decade (CLIA, 2016). Nowadays, passenger ships are one of the largest ships in the world which could accommodate thousands of people during a voyage. Hence, when an accident involving the passenger ship, it will lead to a major loss of lives, properties, and marine environment.

Recent well-published disasters of Ro-Ro/passenger ships together with trends of largely increased capacity of passenger carrying ships have brought the issue of effective passenger evacuation, being the last line defense, in an emergency to the center of attention of the maritime industry worldwide (Vassalos, 2008). Ship evacuation is defined as a quick action taken to move the passenger onboard under the guidance of crew members on board ship to assemble at the muster station with lifejacket donner and waits for the Master order to abandon the ship (Glen & Galea, 2001). Congestion tends to occur during the evacuation in the event of an emergency and it is due to the normal movement of passengers and crews along the escape route, which takes into consideration the possibility of crew members moving in the opposite direction from passengers (IMO, 2014).

The purpose of this study is to assess the evacuation performance of the passenger vessel in Terengganu Water. It is to determine whether the evacuation performance of passenger vessel follow the performance standard set by IMO. Besides that, there is only one study on this issue in Malaysia but no other specific study for passenger vessels in Terengganu Water. This research has its targets for the maritime industry through this simulation study of ship evacuation. To prevent any serious accident involving passenger vessels in Terengganu, all aspects will take into account before doing the simulation for the ship evacuation. It is very important to the maritime industry in Malaysia to make sure all vessel in Malaysia complies with the performance standard issued by the IMO.

2. LITERATURE REVIEW

2.1 Ship Evacuation

Ship evacuation is defined as a process to mobilize the passenger onboard under the guidance of ship's crew to an assembly area before abandon ship (Glen & Galea, 2001). The evacuation of a large passenger vessel is usually a two stages process with an assembly and an abandonment phase. In the assembly stage, passengers, after receiving the initial notification to evacuate in the event of casualty such as collision, grounding, fire, flooding, etc., will moves toward the muster station under the guidance from crew members and assemble there, getting ready to embark onto survival craft with life jacket worn. While in the abandonment stages, passenger will embark onto life boat, life raft, survival craft or other vessel after the receiving the order to abandon the ship from Master. The entire evacuation

process consists of (International Maritime Organization, 2008):

1. The announcement in the event of emergency must be made by Master to ensure the crew members aware of the situation and carry out their assigned responsibilities;
2. Master must contact the base port and report the emergency to authority for rescuing operation;
3. Passengers assemble at muster station must put on life jacket;
4. Crew members shall man the survive craft and emergency stations;
5. All the machineries onboard and the oil fuel supply lines must be shut down;
6. The announcement of evacuating shall be made by crew members through the PA system;
7. The survival craft and marine escape systems, as well as rescue boats, are deployed after announcement made;
8. The survival craft will be lowered down and prepared;
9. Crew members in charge of managing the passengers;
10. The passengers will evacuate in a uniform manner for smooth flow of performance under the guidance of crew members;
11. The crew members shall ensure that all the passenger have left the craft;
12. The crew members will evacuate at the muster station;
13. The survival craft will be released from the craft; and
14. The survival craft will be put up into position by he rescue boat, where provided.

2.2 Factor Affecting Evacuation Performance

Based on the past study, there was some factor affecting the evacuation performance:

- Configuration
- Population
- Environmental
- Procedural
- Behaviour

2.3 Category of Craft

The high-speed crafts operate in the maritime industry are divided into two categories: category A craft and category B craft (International Maritime Organization, 2008).

a) Category A

In this category, the craft is also known as an assisted craft. It is a craft where the rescue assistance is readily accessible with the limited total number of passengers, thus the limitation in active and passive protection can be authorized.

b) Category B

The craft fall in this category is known as an unassisted craft. It is a further growth of high-speed craft into a larger craft. When the rescue assistance is not readily accessible unlike category A craft or when the total number of passengers is an unlimited, additional requirement on the active and passive safety precautions is required. These are to provide a safe-sheltered area onboard, dismissal of vital system, increase the watertight, and the structural integrity as well as to provide full fire extinguishing capability.

2.4 Performance Standard

The formula below shows the equation to calculate the evacuation time based on standard performance ruled by IMO.

$$evacuation\ time\ (minutes) = \frac{\text{SFP} - 7}{3}$$

a) The SFP time is the protection duration for areas of major fire risk.

b) The division by 3 is the division for the safety factor that includes the passenger ages and condition, restricted visibility due to smoke, effects of waves and craft motions during an evacuation, as well as travel and embarkation times. The safety factor also considers any infringement to the procedure of evacuation.

c) The subtraction of 7 minutes is the duration commenced from the initial detection and extinguishing action for category A craft. For the category B craft, the 7 minutes duration includes the passenger awareness time, duration for the passenger to travel towards the muster station as well as the duration needed for crew members to man emergency stations.

According to the guideline (International Maritime Organization, 2005), the performance standard for high-speed craft such as follow must be complied: $tM+tE \leq \frac{SFP-7}{3}$

where;

a) Ideal deployment time (tM) is the duration needed for the preparation and launching of MES and the first survival craft in calm water.

b) Ideal embarkation time (tE) is the duration needed for the all the passenger and crew members to embark onto the survival craft from when the evacuation commenced with craft float in a harbour with calm conditions and all the machinery and equipment

operate in normal seagoing condition, as described in 4.8.7.1 of the HSC Code. $tI+tE \leq \frac{SFP-7}{3}$

where;

a) Ideal travel time (tI) is the duration needed for the slowest group of people to arrive at the embarkation point in a calm water condition. If it is stated otherwise in the evacuation procedure, the number of slowest group of people shall be assumed to be equal with the capacity of the largest survival craft onboard.

b) The slowest group of people here is defined as the group of people that has the longest travel time as calculated according to the guideline.

3. METHODOLOGY

3.1 Area of Interest

This research conduct is to assess the evacuation performance of the existing Laguna Redang passenger ferry which used to transport people from Kuala Terengganu to Redang in Terengganu. Redang Island is an island in Kuala Nerus District, Terengganu, Malaysia. It is one of the largest islands off the east coast of Peninsular Malaysia. It is famous for its crystal-clear waters and white sandy beaches. It is one of nine islands, which form a marine sanctuary park offering snorkeling and diving opportunities for tourists.

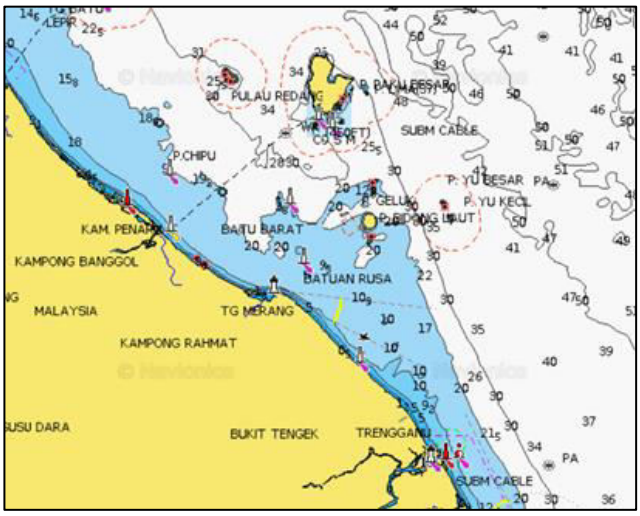

Figure-1. Area of research (Source: Navionics, 2020).

3.2 Methodology

The figure below shows the flowchart of the research activity during the study.

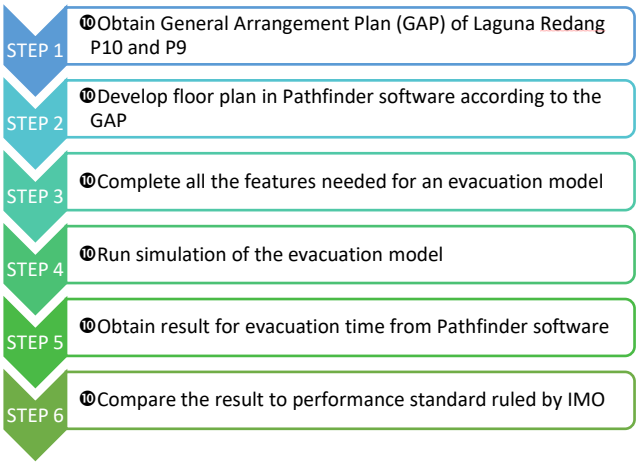

Figure-2. Flowchart of research activity.

A lot of reading needs to be done to gain as much information and idea from publications, earlier study, or mass media. The publications are the data that collected frequently in various aspect and later published so the people of interest can use the data. For an instant, statistic registration, annual report, demographic info, etc. When an enormous number of earlier studies done for one scope, the required information for the research can be obtained from here. The data from the mass media is the information published in the internet or journal. The first objective of this paper which is the factors affecting evacuation performance was obtained from the earlier studies and the performance standard was obtained as per stated in the guideline provided by IMO. The last objective of this research can be achieved by generating the simulation in software Pathfinder. But some steps need to be completed to achieve it.

Firstly, the General Arrangement Plan (GAP) needs to be obtained before generates the evacuation model. So, a site visit is the best method to use to collect as much as possible data for the research. A site survey is defined as appraisal at working area to gather data for design purposes or as an initial step to complete the requirement of an outdoor task. In this paper, the site survey was done by visits to the Laguna Redang jetty at Teluk Pasu, Kuala Terengganu. The passenger vessels which were used in this research for evacuation simulation is Laguna P9 and Laguna P10 from Kuala Terengganu to Pulau Redang. It was done to obtain the vessel's General Arrangement (GA) plan. The GA plan of the vessel is usually hung at the vessel's wall and it comes along with the detailed information of the vessel. So, all the information needed for evacuation simulation can be found in the vessel GA plan. Besides that, the size of main door, exit door, stairs and embarkation station were obtained to generate the evacuation model for the passenger vessels.

Next, software Pathfinder Thunderhead was used to develop the floor plan according to the GA plan of both passenger vessels. This software is mainly used to create an evacuation simulation for building. But it was suitable to generate the evacuation model of the vessel. The

evacuation model of both vessels was created based on the GA plan. The GA plan image for both vessels in JPG image form was imported into the software to develop the evacuation model. So, the evacuation model generated based on the GA plan and some information such as size of doors and stairs which is very important in the evacuation process.

After that, to run the simulation, all the features must be completed such as the walking speed, the average size of occupants, and the total amount of the occupants. The total amount of occupants used for each vessel was based on the total capacity of passenger including the vessel crew which can be get from the GAP. The normal walking speed for the human is 1.4m/s. But, the walking speed of the occupants was modified in accordance with the regulation issued by IMO. For instant, the speed of a person climbs up the stair is 0.44 m/s, and climbing down the stair is 0.55 m/s while the normal walking speed at the corridor or hallway is 0.67 m/s. The height and the size of the occupants were all standardized into one size which is, 170cm and 40cm respectively.

Then, the simulation can be run to get the evacuation time of both passenger vessels. The simulation will take some time to complete based on all the features. If there is any fault when making the floor plan, the simulation cannot be complete easily. But the software already recommends some tips to complete the simulation process. After the simulation has completed, the result for evacuation time for passenger vessels Laguna Redang P10 and P9 was produced.

The last step is to compare the evacuation time from software Pathfinder with the performance standard ruled by IMO. Some calculation needs to be done in order to find out the evacuation time for both passenger vessels either comply with the performance standard.

4. RESULT AND DISCUSSIONS

4.1 General Arrangement Plan

Usually, the GA plan of a vessel hangs on the wall in the vessel. It contains the information such as layout of the vessel, for an instant, the location of escape routes, muster and embarkation station where survival craft situated; dimension of the vessel such as the length overall, length between perpendiculars, beam, depth, designed draft, and designed speed; and the detailed information that includes the load capacity, and type of main engine used.

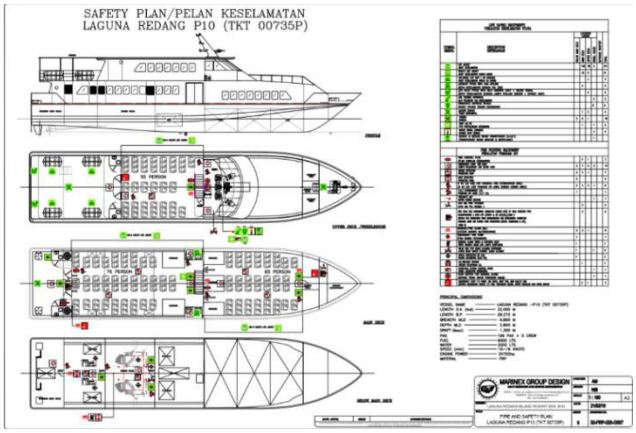

Figure-3. The GA plan of Laguna Redang P10.

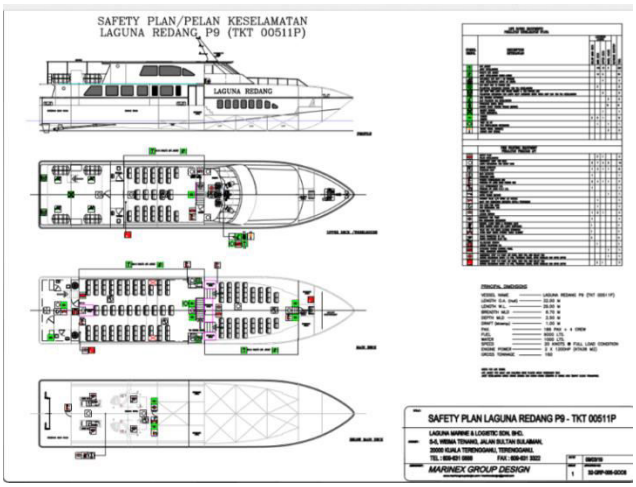

Figure-4. The GA plan of Laguna Redang P9.

4.2 Evacuation Model

By using the Pathfinder software, an evacuation model according to the real scale of passenger vessel was developed based on the GA plan obtained. The 3D simulation of the vessel was developed.

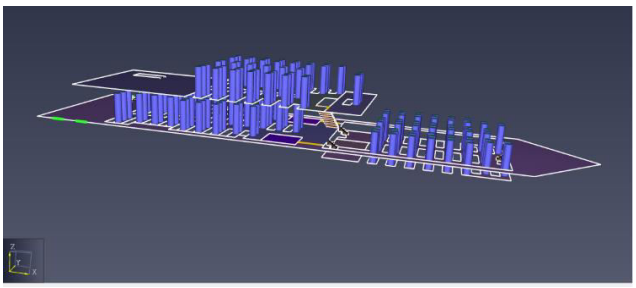

Figure-5. 3D evacuation model of Laguna P10.

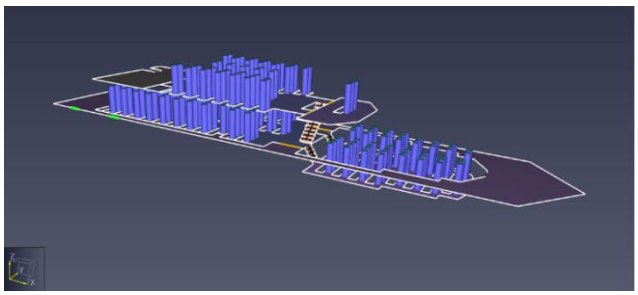

Figure-6. 3D evacuation model of Laguna P9.

4.3 Result of the Simulation

4.3.1 Laguna Redang P10

The figure below shows the evacuation time, the graph, and the comparison to the performance standard ruled by IMO of Laguna Redang P10.

```
Completion Times for All Occupants (s):
  Min:                  6.5   "00003"
  Max:                398.6   "00178"
  Average:             98.3
  StdDev:              83.7
```

Figure-7. Completion times for Laguna P10.

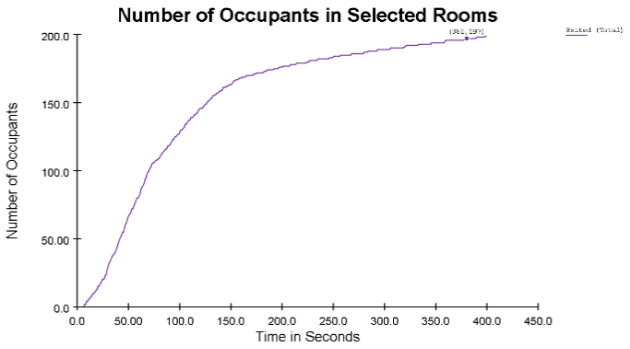

Figure-8. Graph evacuation passenger of P10.

Performance Standard

$$evacuation\ time\ (minutes) = \frac{\text{SFP} - 7}{3}$$

SFP= 60 minutes

$$evacuation\ time\ (minutes) = \frac{60 - 7}{3}$$

Overall evacuation time: $t_M + t_E = 150s + 398s$
$= 548s \leq 1060s$
$t_I + t_E = 70s + 398s$
$= 468s \leq 1060s$

4.3.2 Laguna Redang P9

The figure below shows the evacuation time, the graph and the comparison to the performance standard ruled by IMO of Laguna Redang P9.

```
Completion Times for All Occupants (s):
  Min:                  7.6   "00058"
  Max:                362.8   "00164"
  Average:             86.8
  StdDev:              70.4
```

Figure-9. Completion times of Laguna P9.

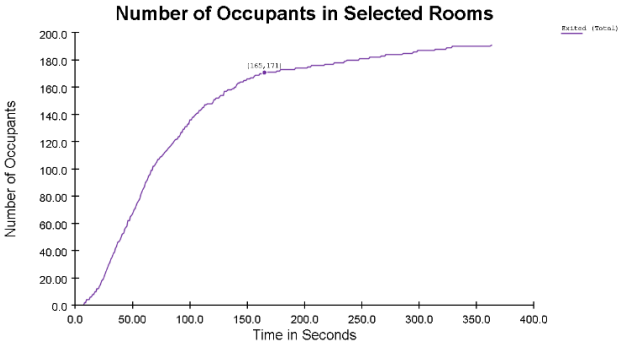

Figure-10. Graph of evacuation passenger P9.

Performance Standard
SFP= 60 minutes

$$evacuation\ time\ (minutes) = \frac{60 - 7}{3}$$

Overall evacuation time: $t_M + t_E = 150s + 362s$
$= 512s \leq 1060s$
$t_I + t_E = 131s + 362s$
$= 493s \leq 1060s$

5. DISCUSSIONS

Based on the simulation result of the evacuation model and the result from 4.3, both passenger vessels have complied with the performance standard and requirement ruled by IMO. To develop and run the simulation and eventually produced the result of the evacuation time, some problems must be faced. The major problem was when the occupants get stuck during running the simulation. So, a solution needs to be found out to complete the simulation. But that is a common problem of using this software if details of the floor plan have not been checked properly. A better accurate result of the simulation would be obtained when higher detail of the features especially in the accommodation space is input into the software. However, a higher detail simulation's model would require a longer time to develop.

6. CONCLUSIONS

In conclusion, this research had run an evacuation simulation to assess the safety level passenger vessel operating in Terengganu waters by using simulation software. Based on the results obtained, the evacuation time of passengers on Laguna Redang P10 and Laguna Redang P9 have complied with the requirement and performance standard set by IMO. Both objectives listed before conducting the research have been achieved. The result of running a full evacuation exercise by using real people and the results of the computer simulation may differ. This research can be used as the first step for an

interest group of people or organisations to run the passenger evacuation simulation on the existing passenger vessels that are operating in Malaysia, which to determine whether it complies with IMO standard.

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